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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Steam Power Plant Prime Movers and Their Lubrication

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS

By Way of Introduction

"GOOD wine needs no bush." Nor does the article which makes up the following pages need any advertisement of its merits.

The thing we would like to do here is to point out that our Editors have plunged right into the subject of Lubrication.

They have not introduced it with any description of units or elaboration of principles of operation.

This was done in the belief that the practical man must know these things for years. All we hope to do is to give some practical reasons for the choice of certain types of lubricants, illustrate the advantages of certain methods of application; and on the last page to offer some practical recommendations giving definite brand names of Texaco Lubricants exactly suited to the conditions outlined.

We wish to say further that any engineer, anywhere, can accept these recommendations with utmost confidence. Behind them are years of experience in the refining and manufacturing of lubricants and in observation and checking of the oils at work.

We will not say anything about the modern, carefully conducted Refineries in which Texaco Lubricants are made, or the care with which these Products are inspected and shipped, but we would like to mention the experience in observing them at work.

Texaco recommendations are practical and represent the best ideas of Texaco Lubrication Engineers from all over the world. And that we respectfully submit means a fund of experience that no operating engineer could begin to acquire in a lifetime.

For, look you, if an operating engineer were to change his position every six months, in twenty-five years he would only get into half a hundred plants—not all of them different, which you will plainly see means considerably less than a single day's work to the whole corps of Texaco Lubrication Engineers.

So, then, you can confidently order any of the Texaco Lubricants recommended for your type of unit from any of our more than eight hundred stations and warehouses.

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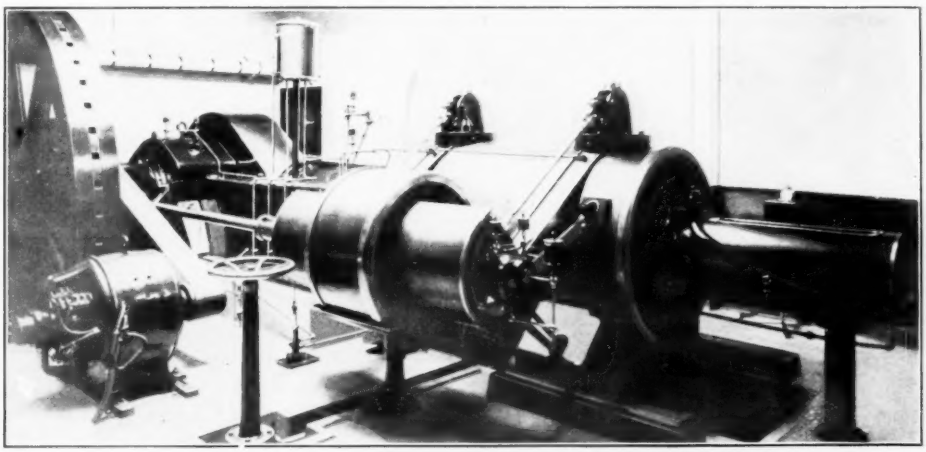


Courtesy of S. F. Bowser & Co., Inc.

Fig. 1.—A Nordberg poppet valve engine equipped with an individual oiling and filtering system.

Steam Power Plant Prime Movers and Their Lubrication

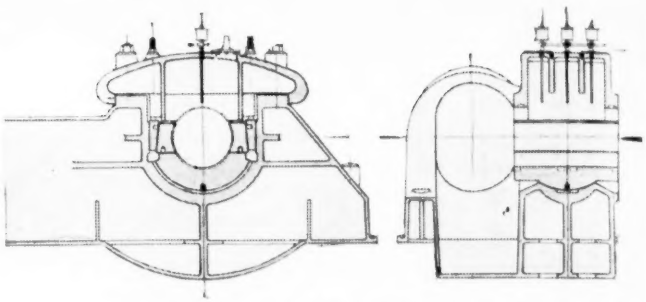
THE relation that exists between scientific lubrication and the fuel and power problems of the industrial world is oftentimes lost sight of by the Power Plant Management.

Periodic coal and fuel oil shortages, uncertain markets and wavering prices, super-power developments, and the ceaseless efforts to increase efficiency and reduce costs seem very frequently to totally eclipse (in apparent importance) the factor which is in reality the keynote of successful plant operation, i. e. *LUBRICATION.*

Without lubrication and lubricants we would be little more advanced in engineering civilization than the stone age. Power,—the ambition of man since he first discovered how to harness beasts of burden to a crude cart,—is as dependent upon lubrication for its continued production as it is upon mechanical energy. In effect, the lubrication of machinery is as essential to the efficient production of power, as are the natural elements such as fuel and water.

Nor can we any longer regard lubrication as a mere matter of wielding an oily swab or poking the spout of an oil can into the vitals of a

piece of machinery. High speeds, a marked increase in pressures, and the demands for continued operation have all contributed to bring about a development of automatic lubrication that is little short of phenomenal. The personal element had to be eliminated as far as possible, and for this reason lubricating systems have been designed primarily to give positive and fool-proof service. In conjunction with the advancement in refining methods which has led to a production of lubricants of decidedly accurate properties, an era of *scientific lubrication* has been entered upon.



Courtesy of Allis-Chalmers Manufacturing Co.

Fig. 2.—Sectional view of a main bearing for a heavy duty Corliss engine, showing oiling details.

In fact, today, a selection of lubricants adapted to the service intended and the system of lubrication, will insure continued production far more positively than any other element of power plant operation.

Steam power plant lubrication is, therefore, of decided interest to us all; to the producer from the viewpoint of reducing operating expense and friction losses as much as possible; and to the consumer from the viewpoint of continued service, and freedom from the old "lights out" conditions of not so many years ago, whenever a turbine or generator bearing burned out, etc.

Reciprocating Steam Engines

Lubrication of reciprocating engines can be broadly classified as internal and external, or in other words, as applying to (a) steam cylinders and valve chests, and (b) to bearings, pins and guides.

Steam Cylinder Lubrication must be studied in conjunction with steam pressure, temperature, and moisture conditions, engine design and construction, and operating speeds. We can usually attain best results by regarding the above from the viewpoints of:

1. What the oil must lubricate.
2. How it must be applied.
3. The operating conditions it must meet.
4. How to select an oil best suited to these conditions.
5. How to determine if lubrication is correct.

What the Oil Must Lubricate

In developing what the oil must lubricate we have primarily to deal with engine design and construction. The function of a steam cylinder oil is to lubricate every sliding surface which is either in direct contact with the steam, or subject to its pressure and temperature. Therefore valves, valve rods, valve seats, cylinder walls, pistons and piston rods are involved. These parts are not always subject to the same pressure and temperature conditions, yet the one oil must serve throughout, and therefore be sufficiently flexible in operation to produce efficient lubrication wherever necessary.

Steam valve design is the governing factor in cylinder lubrication. There are, broadly, four types of such valves, i.e. the slide or D-valve, the piston valve, the Corliss and the poppet valve. Of all, the common slide valve is the most difficult to lubricate due to inequalities of pressure and the consequent "wiping" action it exerts upon the lubricated valve seat. Therefore the oil film must be continuously renewed. With the piston valve, on the other hand, the steam pressure is balanced, and as a result there is less tendency for the oil to be squeezed or wiped from the valve seat. As a result, piston valve engines can operate under considerably higher pressures than slide or Corliss valve engines.

The Corliss valve is a slide valve to the extent that it is subject to a sliding action on its curved seat similar to the D-valve. There is not as great an area of contact, however, hence, although it is subject to unbalanced steam pressures, this type of valve can carry higher pressures than a plain D-valve. The chief difficulty with a Corliss valve is to maintain a suitable

film of lubricant at the end of the valve. Therefore individual feeders for the lubricant are usually installed at such points.

Poppet valves while reciprocating in action are not subject to sliding on the valve seat. As a result lubrication at this point is relatively unnecessary. Valves of this type are also balanced as to steam pressure; hence they are capable of operation under higher pressures the same as piston valves. They are extensively used in certain types of uniflow engines. Poppet valves require lubrication of the stems only. It is essential to regulate the flow of lubricant carefully and to guard against an excess, otherwise abnormal carbonization of the oil will occur and the valves may stick.

Valve, piston and tail-rods require quite as efficient lubrication as valve seats and cylinder walls if they are to operate effectively. While it is usually considered the duty of a cylinder oil to lubricate these latter, we must never forget that detrimental results may occur if they are neglected. In general, valve, piston and tail-rods will receive sufficient lubrication from the oil in the steam. It is customary, however, to either install auxiliary sight feed oil cups or make some other provision for oiling the rods externally at regular intervals. We must remember that both valve and piston rods are very accurately machined and adjusted; and often metallic packing is used, therefore any overheating due to lack of lubrication might affect the packing or cause a change in alignment, with ultimate damage to the internal mechanism of the engine. Poppet valves, in particular, will tend to stick, etc., unless the valve stems are well lubricated and free from carbon.

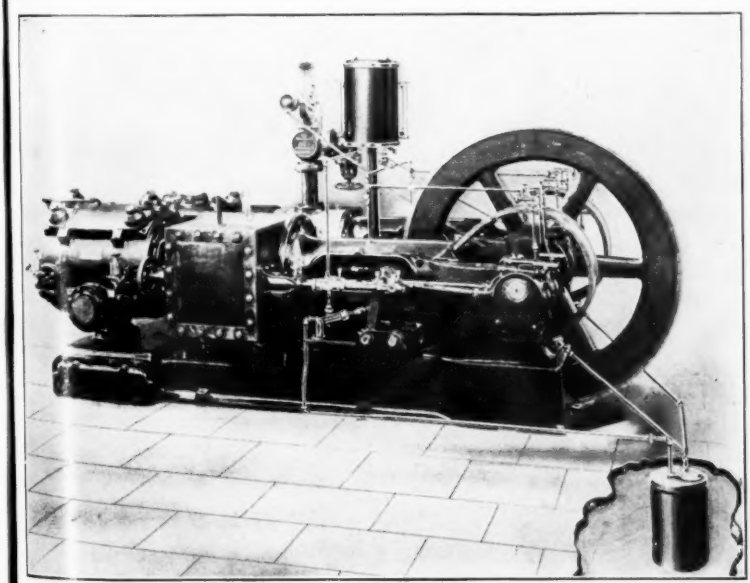
Method of Application of the Lubricant

Having reviewed the parts of a steam cylinder requiring lubrication, we are next concerned with the application of the lubricant. The cylinder is lubricated by either one of two methods: (1) Where the oil is applied directly to each of the separate wearing surfaces, and (2) Where the oil is fed into the steam line between the throttle valve and the steam chest, the steam serving to atomize it and carry it to all moving parts within the valve chest and cylinder.

Direct application of steam cylinder oils by means of individual oilers installed on the valve chest and cylinder is the more crude and uncertain of the two methods. In this case the lubricant is fed drop by drop into the engine, being spread over the wearing surfaces by the movement of the valve and piston. Valve, piston rod, and tail-rod glands are often similarly equipped with drop feed oilers.

It is perfectly evident that such a method of lubrication, while probably not objectionable in the case of a single cylinder engine, would be decidedly cumbersome and unreliable if applied to a multiple cylinder unit. In fact there would be so many points requiring attention that the possibility of lack of lubrication would be very great.

For this reason steam cylinder lubrication by means of injecting oil into the steam line, using a hydrostatic or mechanical force feed lubricator, is regarded



Courtesy of S. F. Bowser & Co., Inc.

Fig. 3.—Illustrating the manner in which an individual oiling and filtering system can be applied to an air compressor installation.

as far more dependable and conducive to increased efficiency. The fact that the steam reaches practically all of the surfaces requiring lubrication, in its passage through the engine insures the transmission of the particles of oil which it carries, to these parts. However, sufficient oil must be fed to the steam line and the point of introduction of the lubricant must be located at a suitable distance beyond the throttle valve and the steam chest to enable the steam to completely exercise its atomizing effect. Oftentimes this procedure is spoken of as "lubricating the steam". Complete atomization is the secret of steam cylinder lubrication. If any of the oil is carried into the cylinder in liquid state its lubricating effect is lost, as it will either be swept out prematurely by the rush of exhaust steam, or not be able to distribute itself uniformly over the wearing surfaces.

The Point of Introduction is, therefore, of the utmost concern. In general, if this is located at a distance of from six to eight feet above or preceding the throttle valve, unless abnormal conditions arise, atomization can be depended upon to be complete by the time the lubricated steam reaches the throttle valve, and the latter will be quite as effectively lubricated and rendered capable of as efficient operation as the working parts of the engine.

If the point of introduction is located too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be a possibility of the oil particles being thrown to the walls of the steam line, from whence a flow of liquid lubricant will occur to the valve chest. In effect this might well be termed condensation of the lubricant, and it will be quite considerable if there are any bends or other pipe fittings located between the lubricator and the valve chest. Thus in extreme cases where such conditions occur, it may often be necessary to install auxiliary direct-feed lubricators upon the valve chest or cylinder, even though a waste of oil will be probable. In multiple expansion engines equipped with receivers between the cylinders, the flow of steam may often be so checked as to cause the oil particles to be thrown down and deposited in the receivers. Where such is found to occur it will be advisable to install lubricators on each steam chest. The oil feed in such cases, however, should be carefully regulated, inasmuch as but little make-up lubricant is usually necessary to compensate for that lost in the receivers.

Granting that automatic lubrication will usually be adaptable to the average steam engine, we are therefore concerned with *two types of lubricators*, i.e. (1) The hydrostatic and (2) the mechanical force feed type.

The hydrostatic lubricator embodies the principle of forcing the oil, drop by drop, into the system by means of a head of water which is maintained by condensing of the steam. A hydrostatic installation cannot be depended upon to be absolutely positive due to the more or less erratic nature of the conditions to which it is subject. For example, a change in temperature will affect the viscosity of the oil, the size of the globules fed, and consequently the regularity of the flow. In addition, the flow of oil will be independent of the speed of the engine, hence the working parts of the latter will seldom receive exactly the correct amount of oil to meet the conditions of operation.

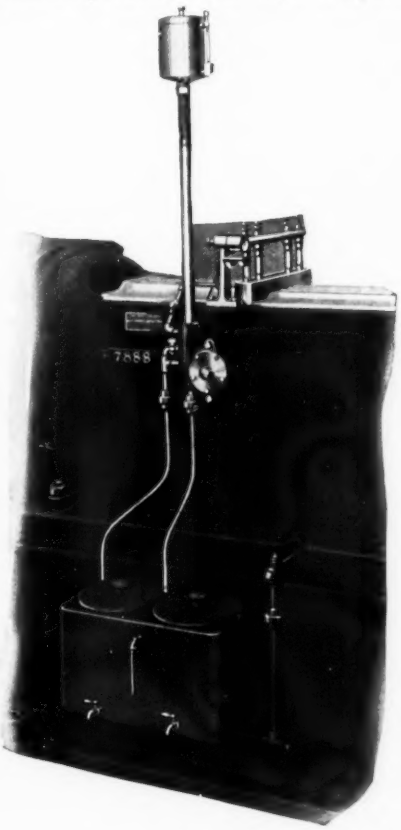
The mechanical force feed lubricator more or less overcomes certain of these objections by virtue of the fact that it is connected directly to some reciprocating part of the engine. Consequently oil is fed into the system at a rate which varies directly with the speed. Such a lubricator functions only when the engine is operating, hence there is little possibility of wasted oil or the flooding of the system. An efficient mechanical lubricator should feed the same amount of oil regardless of the temperature, viscosity or amount of oil in the reservoir. In general, while a device of this nature can be used with either a direct feed or an atomizing spoon, the spoon is more commonly used.

Operating Conditions that Must Be Met

The principle operating conditions that a cylinder oil will have to meet are: steam pressure, temperature, velocity, moisture in the steam, degree of superheat, priming, foaming, boiler compounds, and the use (if any) which is to be made of the exhaust steam.

While steam pressure alone has but little influence upon a cylinder oil, the temperature associated with the pressure, as well as the degree of superheat to which the steam may be subject, has a very marked effect. The usual operating

temperature in the steam cylinder and valve chest must be taken into consideration when we are selecting the cylinder oil due to its more or less effect upon the viscosity of the oil film on the cylinder walls and valve seat. In other words viscosity will be decreased accordingly as steam temperatures are increased. Therefore, where operating with high temperature



Courtesy of Skinner Engine Company

Fig. 4.—An automatic lubrication system which accomplishes purification and cooling of the engine oil, the separation of entrained water and re-delivery of the oil to the engine bearing in a complete cycle of events.

saturated or superheated steam a heavier bodied oil should be used.

Steam temperature and velocity affects the atomization of the cylinder oil to a marked extent. Thus, the higher the temperature and velocity the more readily will a heavy bodied oil be atomized, due to the reduction in viscosity which occurs at the temperature of atomization.

From the viewpoint of the actual composition of a cylinder oil, the question of moisture in the steam is the most important factor involved. Steam will always contain a certain percentage of moisture unless it is superheated to a sufficient extent to counteract any line and cylinder condensation, which may be brought about by the cooling effect of the piping and cylinder walls, and the expenditure of heat by the expansion stroke. The presence of moisture in steam will usually result in a film of straight mineral lubricating oil being rapidly washed off from the cylinder walls and other surfaces with which the steam comes in contact. Therefore, to secure proper lubrication under wet steam conditions it is necessary to either increase the rate of flow of the straight mineral oil, or else substitute an oil which contains a certain percentage of fatty compound such as lard oil, degras, or tallow.

The practice of using a straight mineral oil to lubricate wet steam is customary only where the presence of a fatty oil in the exhaust steam is objectionable. The increased amount necessary to insure proper lubrication will often result in imperfect atomization. As a consequence, oil accumulations in the cylinder will be prevalent and carbon deposits may be developed. In poppet valve engines carbon formation of this nature may often cause imperfect operation of the valves.

Where a compounded oil is used an emulsion is developed by the moisture in the steam reacting with the fatty component. The lubricating film thus has a greater affinity for the cylinder walls and other wearing surfaces and becomes highly resistant to the washing action of the water in the steam. Naturally the greater the percentage of moisture in the steam the higher should be the fatty compound content of the lubricant. In general the compound should not exceed 10%. We must remember that an excessive amount of fatty compound, beyond that necessary to form the requisite emulsion, will not improve the lubricating value of the oil. In fact, it may even be an objection, especially under continued exposure to high temperatures, on account of the tendency that animal fats have of decomposing and forming carbon under such conditions.

Where the exhaust steam is to be used for feed water heating or in process work of any nature, it is more important than ever to observe caution in selecting and using steam cylinder lubricants. If efficient oil separators are

installed usually the greater percentage of any oil carried over by the exhaust steam will be removed. If, however, separation is not practically complete, oil deposits may result in the heaters or on the boiler tubes. Damage to the latter will be bound to occur ultimately due to uneven heating and blistering, etc.

Selection of Steam Cylinder Oils

Operating conditions, etc., are the controlling factors in the selection of any steam cylinder lubricant. For this reason the essential features influencing the selection of such products have been covered above.

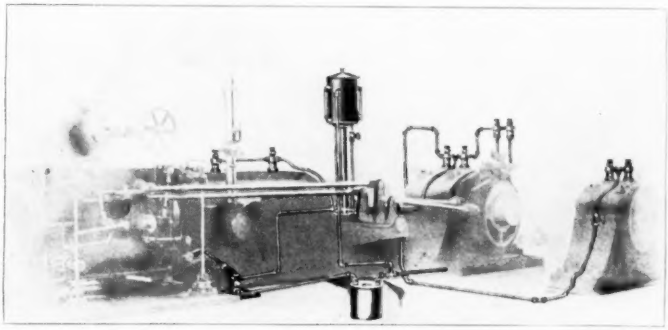
The Determination of Correct Lubrication

Having broadly reviewed the principal elements which normally enter into the selection of proper oils for use in steam cylinder lubrication under various operating conditions, etc., the matter of how to determine whether lubrication is correct is of interest.

In general the real test of a cylinder oil should be the condition of the wearing surfaces upon which it is used. Therefore, hasty decision as to the suitability of such an oil should be guarded against, as time is necessary for the lubricating film to form and function properly. Any test should, therefore, cover a period of several weeks. Then the engine should be shut down, and the cylinder head and valve chest cover removed and the interior examined. If upon immediate inspection the wearing surfaces show a film of lubricant sufficient to penetrate three or four thicknesses of cigarette paper with a brownish stain, they are sufficiently lubricated. If below this film they appear highly polished and of a color varying from bright iron-white to steel-blue, they have been properly lubricated.

Where the surfaces are rough, dry, dull in appearance or rusty, lubrication has either been insufficient or the wrong grade of oil has been used. In addition, if the stain on the cigarette papers appears streaked, blackish or mottled, either the oil has been subject to carbonization or abnormal wear has taken place. Excessive lubrication, on the other hand, will be indicated by pools of oil lying in the bottom of the cylinder or in the counterbore.

Under operation the efficiency of lubrication can be roughly judged by: 1. The film of oil on the piston rod; 2. The amount of oil in the condensate; 3. The action of the valves. A suitable film on the piston rod (unless oil is fed directly to it), minute drops of oil and a milky appearance in the condensate, free action, and little or no noise in valve operation, are indications that the oil is suitable, atomization complete, and the rate of feeding correct.



Courtesy of S. F. Bowser & Co., Inc.

Fig. 5.—Showing details of piping necessary in an individual oiling and filtering system on a simple Corliss engine.

External Lubrication

Engine bearings, guides and pins are, in general, lubricated by one of two methods, using either sight feed oil cups or grease cups; or some form of continuous lubrication.

Oil and grease cups involve intermittent lubrication. In general they are simple in operation, and if properly adjusted will feed the right amount of lubricant to afford sufficient lubrication, with but little waste. However, the tendency is oftentimes to neglect such equipment with the result that considerable direct waste occurs.

Drop feed oil cups require a relatively heavy oil which should be selected for its ability to remain on the bearing surfaces for fairly indefinite periods. As a general rule systems of this nature will require an oil of from 300 to 500 seconds Saybolt viscosity at 100° F. Oftentimes operators will have a tendency to use an

oil of somewhat higher viscosity in order to compensate for wear. This, however, is not good practice inasmuch as higher viscosities give rise to abnormal heating and power consumption.

Continuous Lubrication

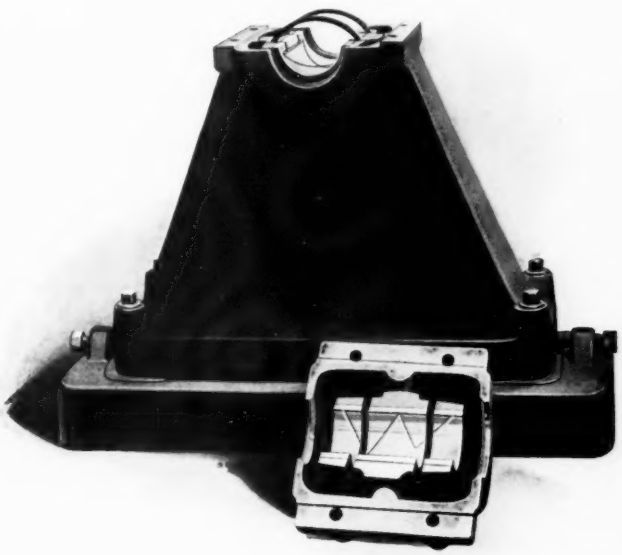
Continuous lubrication involves a directly opposite theory to intermittent lubrication inasmuch as the bearings are literally flooded with an excess of oil over that which is absolutely requisite for proper lubrication. The function of the oil is therefore to act not only as a lubricant but also as a cooling medium to carry off any frictional heat that may be developed in the bearing under operation. This flood of lubricant also keeps the bearing surfaces free from dust, dirt and metallic particles, and thereby reduces the tendency towards abnormal wear, scoring, etc. As a rule the oil from a continuous oiling system is drained to some central point of collection such as the base of the engine, from which it may be removed when desired and filtered or centrifuged in order to effect purification.

Continuous oiling may be broadly grouped into two classifications, i.e. 1. Splash lubrication, and 2. Force feed lubrication.

Splash Lubrication is adaptable to installations where the crankcase is completely enclosed and the entire system oil tight. As a general rule splash systems have some provision installed on the crank for picking up the oil from the base of the machine and transmitting or throwing it to the points it is desired to lubricate. The essential feature of splash lubrication is to maintain a suitable supply of oil in the crankcase in order that the crank or its oil dipper will never miss the surface of the oil.

In equipment lubricated by splash systems a quick water and sediment separation is imperative. The viscosity of the oil in a splash system should, therefore, be as low as is consistent with requirements, in order to insure rapid precipitation. Few lubricants receive any harder service than those involved in systems of this type, since they are used over and over again without purifying or cooling. Wherever the oil serves as a coolant as well as a lubricant, and the cooling advantages of other continuous lubricating systems are absent, it must have a low evaporation factor and a minimum tendency towards decomposition.

Ring and chain oilers are also used to a certain extent in power plant service, and involve flood lubrication within the ability of the rings or chains to transmit the oil to the bearing. The same conditions hold for lubricants for this type of service as have been discussed under Splash Lubrication.

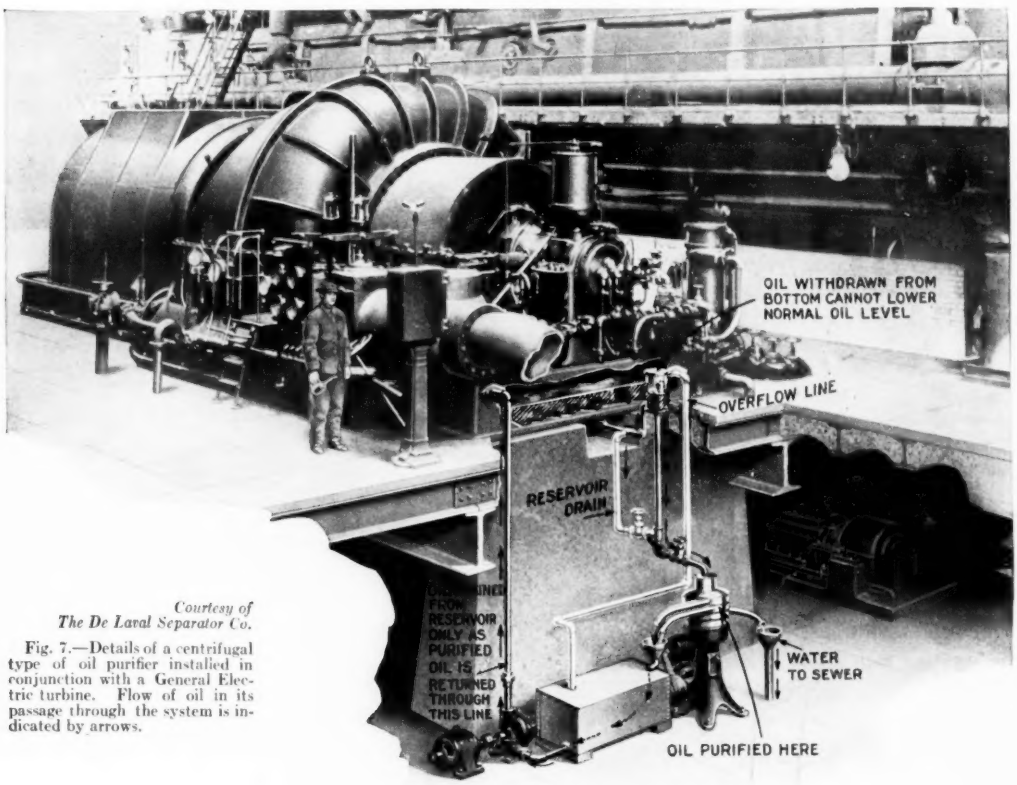


Courtesy of Ridgeway Dynamo and Engine Co.

Fig. 6.—Outboard bearing of a uniflow engine, showing details of bearing cap construction, oiling grooves, and bronze oil rings.

In a Force Feed System the oil is forced into the bearings at pressures ranging from 5 to 15 lbs. per square inch. This impetus to the oil may be obtained either by making use of the action of gravity or employing oil pumps. In the first instance suitable storage tanks are located at a sufficient elevation above the bearings to produce a head corresponding to the required pressure. In the second case an oil pump is installed, the oil being passed in a continuous cycle through the bearings, and then filtered and cooled, etc. Lubricants used in a force feed system have their requirements

controlled to a large extent by operating and constructional conditions. When the system includes ample purifying and circulating capacities the oil will be subject to comparatively light duty, inasmuch as bearings are continually washed out and there is ample opportunity for dirt and water to precipitate. Also, as there is an adequate and continuous flow of lubricant it will be generally unnecessary in such a case to select an oil capable of standing extreme temperatures or loads. It must be remembered that the lighter the oil the lower its internal friction will be. In fact the two essential requirements are that the oil shall not emulsify nor contain any corrosive acids. Emulsification would clog the system, while acids would cause deterioration of the piping, filters, settling tanks, bearings, etc. A pure mineral oil of from 150 to 200 seconds Saybolt at 100° F. will be usually satisfactory for such service.


OIL WITHDRAWN FROM BOTTOM CANNOT LOWER NORMAL OIL LEVEL
OVERFLOW LINE
RESERVOIR DRAIN
FROM RESERVOIR ONLY AS PURIFIED OIL IS RETURNED THROUGH THIS LINE
WATER TO SEWER
OIL PURIFIED HERE

Courtesy of The De Laval Separator Co.

Fig. 7.—Details of a centrifugal type of oil purifier installed in conjunction with a General Electric turbine. Flow of oil in its passage through the system is indicated by arrows.

The selection of Engine Lubricants depends largely, as has been seen, upon the method of application. In general, however, there are certain definite requirements which the oil must possess, such as:

1. Sufficient body or viscosity to prevent metal to metal contact of the surfaces to which it is applied, but not so heavy as to produce high internal friction.

2. An ability to flow readily when low service temperatures are involved.

3. A flash point sufficiently high to indicate that a reasonable factor of safety has been provided, and that loss due to evaporation will be low.

4. Ability to stand up under continued service without any excessive tendency towards decomposition or gumming.

5. Ability to meet special service requirements such as quick water separation and low vaporization, and emulsification.

6. Freedom from impurities or corrosive acids, etc., which might prove injurious to the system.

Steam Turbine Lubrication

Steam turbine service imposes perhaps a more exacting task upon the lubricant than any other type of power plant machine operation. High rotating speeds over extended periods of time, and extremely small clearances between the bearings and journals, require a constant and positive supply of oil which is capable not only of resisting admixture with foreign matter such as water, dust, sludge, etc., but also of maintaining an operating viscosity such that the lubricant will readily circulate to the entire bearing and show a minimum of internal friction.

In general the selection of turbine lubricants will be affected to a more or less extent by:

1. The rotational speed,
2. The size of the bearings, and
3. The clearance space.

Speed of Rotation

Speed of rotation is of importance in that it directly affects the amount of oil which will be drawn through the bearing clearance space. A film of oil is practically always present upon the revolving surface of a properly lubricated journal. Thus, due to the inherent viscosity of the oil, the adjacent layers to that adhering to the metal will be drawn into the clearance space. But their entry will be resisted by the oil already therein which in turn is more or less squeezed out by the weight of the bearing. This latter force is relatively constant, varying only according to the size and weight of the journal. On the other hand, the force of attraction which tends to draw the oil into the clearance space is variable, and directly dependent upon the rubbing speed and viscosity of the oil. Therefore at high rubbing or rotational speeds it is evident that an oil of somewhat lower viscosity will be required to maintain a suitable film in counteraction to the force of expulsion due to the weight of the journal.

The Size of the Bearing

The size of the bearing enters into the question in that it involves the weight and operating pressure to which the oil film in the clearance space is subjected.

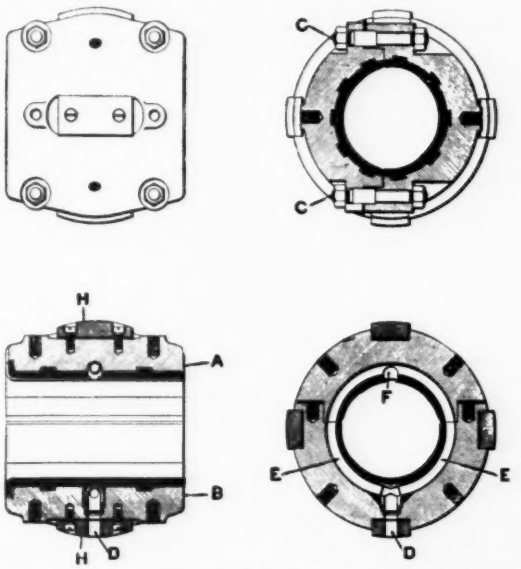
Clearance Space

The clearance space is of importance in that it directly governs the maintenance of the oil film. That is, the greater the clearance and the more accurately this is expanded (or the bearing edges chamferred) at the point of entrance of the oil, the more readily will the revolving journal draw a suitable film of lubricant through the bearing. By expanding or chamferring, as above, the formation of a wedge of oil is made possible, the oil entering at the base or thicker part of this wedge, and passing into the clearance at the point.

In connection with the above, there are certain characteristics pertinent to the oil which must also be studied. Thus, (a) the viscosity; (b) the cooling effect of the oil; (c) its evaporative tendency, and (d) the tendency towards decomposition, emulsification, and sludge formation all are of distinct importance.

Viscosity and Fluid Friction

The function of fluid friction according to the theory of lubrication is to eliminate metallic or solid friction by the substitution of the fluid friction of an oil film. Therefore, we have to deal with the friction which arises when par-

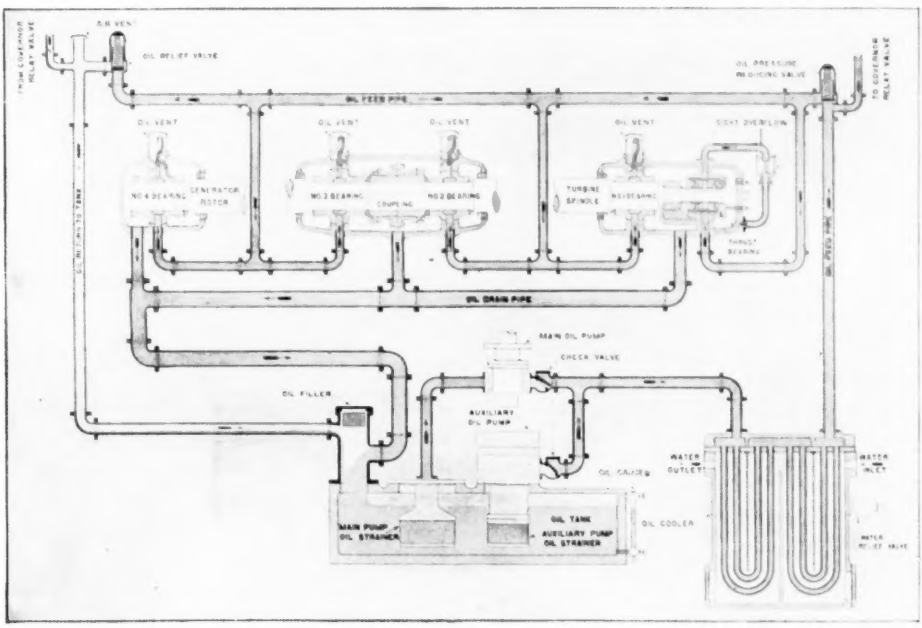


Courtesy of Westinghouse Electric & Manufacturing Co.

Fig. 8.—Details of a self-aligning horizontal split babbitt turbine bearing. Oil enters the bearing shell at "D", passes around the passages EE, under moderate pressure, and comes into the bearing proper at F.

ticles or films of oil move or slide past each other.

Viscosity is a controlling element in this regard, since it resists this change in the relative position of the oil particles, or the sliding of adjacent films over one another. Therefore frictional losses can never be entirely eliminated, and a certain amount of power must always be used to overcome fluid friction. As we decrease viscosity, however, within reasonable limits, fluid friction can be reduced, but it is in larger installations to flood the bearing with oil under a certain uniform pressure. Part of this oil circulates through the clearance space, the excess serving as the coolant. The cycle of operation is made complete by the draining of this lubricant back into a suitable sump tank where it is cooled, and then subjected to more or less purification before re-using. In general, bearing temperatures will depend upon the design of the bearing, the viscosity of the oil and the volume supplied to the bearing.



Courtesy of Allis-Chalmers Manufacturing Co.

Fig. 9.—Diagram showing the scheme of lubrication for a modern steam turbine. Oil travel throughout the system is indicated by arrows and can be readily followed.

never safe to carry this too far as it is very possible to reach a point where the oil will be so light in body as to be unable to support the weight of the bearing or resist operating pressures.

Cooling Effect

One of the chief functions of a turbine oil is to carry away to as great an extent as possible, the heat generated during operation. If this is not brought about, the viscosity and hence the supporting ability of the oil, will drop to a certain extent, oftentimes even to such a degree as to render the oil incapable of keeping the metallic surfaces apart. So it is customary

Evaporative Tendency

Any petroleum oil when subjected to churning or agitation in the presence of air will evaporate to a certain extent, depending, naturally, upon its characteristics. Although the average turbine oiling system is generally tightly enclosed and built to operate as free from oil leakage as possible, a certain amount of the lighter more volatile components in the oil will always find a means of escape from the system, especially under higher operating temperatures. As a result, the remaining oil will gradually tend to increase in viscosity. However, the more highly refined an oil, the lower evaporation will it show under continued operation.

Decomposition, Emulsification and Sludge Formation

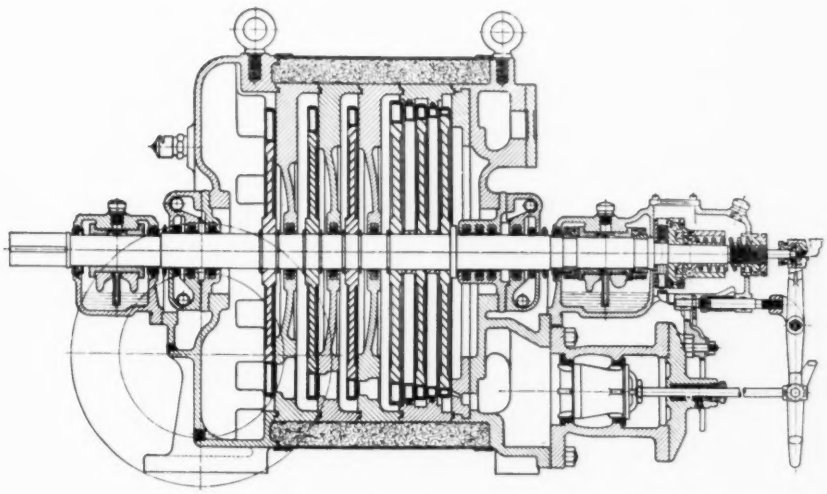
The fact that the above are inter-related to a certain extent warrants their consideration collectively. Decomposition and oxidation of turbine lubricants are not only the most objectionable features from an operating viewpoint, but also the most prevalent effects of high bearing temperatures. However carefully refined a turbine oil may be, a certain amount of oxidation and decomposition will take place if it is subjected to abnormally high temperatures in the presence of air. Such reactions are indicated by a darkening in the color of the oil. From a lubricating viewpoint, however, this alone has yet to be proved a detrimental feature. As a result of this change in characteristics, however, gumming and emulsification will result, especially if water is present.

The most important effect of this gradual decomposition and oxidation of turbine oils is the formation of sludges. These, when agitated with water may form emulsions. The more highly refined the oil, however, the more rapidly will it separate from water. It is generally admitted that water can not be kept out of a turbine lubricating system, there being so many possible sources of entry such as leaky cooling coils or water jackets, moist air drawn into the system, steam leaks via the stuffing boxes, etc.

The only alternative, therefore, is, first: to select only the most highly refined, pure mineral lubricant, and second: to so design our system that every possible means will be available for the removal of water and sludge from the oil. If the system is inadequate for the service, or, in other words, if too rapid circulation of the oil is necessary, any entrained water and sludge will not have sufficient time to settle out, and the resultant continued agitation of any oxidized constituents will promote abnormal emulsification, thickening of the oil, the retention of abrasive particles, and ultimately clogging of the oil piping. In general we may state that, given two oils of like quality, the one having the lower viscosity and specific gravity will show a readier separation from water.

It is therefore evident that owing to the high speeds at which turbines are operated, the importance of the selection of proper lubricants can not be over-emphasized. In general it may be stated that a turbine lubricant should be a high grade filtered pure mineral product, free from acid, able to separate quickly from water, sludge or other foreign matter, low in emulsification tendency, and having as low a viscosity as possible commensurate with the operating and constructional conditions involved.

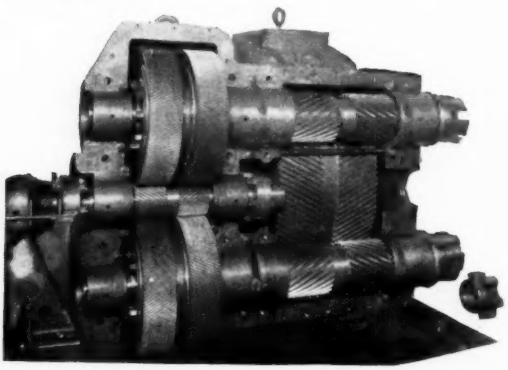
Turbine bearings may be either lubricated by ring or chain oilers or some form of self-contained force feed circulating system. As a gen-



Courtesy of Kerr Turbine Company

Fig. 10.—Section through a type of turbine that is often adapted to driving power plant auxiliaries. Ring oilers are used for the lubrication of the bearings of this machine.

eral rule ring oilers, etc., are not adaptable to machines above 300 H.P. in capacity. For ring and chain oil lubrication the viscosity of the oil will depend upon the extent of heating from external sources and the capacity of the oil reservoir, as well as the extent to which the oil may be cooled by radiation. Ordinarily an oil having a viscosity of approximately 150 seconds at 100° F. will be suitable for such service. On the other hand abnormal temperature conditions may sometimes require an oil of much greater body.



Courtesy of General Electric Company

Fig. 11.—Double reduction gears in which a reduction from 3200 R.P.M. to 137 R.P.M. is attained; installations of this type are much used in marine service.

Force feed lubrication involves the supplying of a positive flow of oil to all bearings under a definite pressure and is used on practically all larger installations. Owing to the fact that the constant pressure insures comparatively flood lubrication the viscosity of the oil can usually be maintained within low limits. In systems of this type an oil having a viscosity of from 145 to 200 seconds Saybolt at 100° F. will give desirable results.

When reduction gear apparatus is involved the same oil is generally used to lubricate both the bearings and gears. As a result we must select an oil suitable for the heavier duty, i.e. the lubrication of the gears, and yet not be too heavy at the operating temperatures to satisfactorily serve the bearings. Turbine bearings will seldom require an oil higher in viscosity than 200 seconds Saybolt at 100° F. However, when the oil is used for both bearings and gears on stationary equipment, the viscosity should not be lower than approximately 300 seconds. On the other hand, the viscosity will depend almost entirely upon the amount of vibration which occurs between the gears.

Where this is excessive it may often be necessary to select an oil as high as 500 seconds in viscosity, and in marine service 750 seconds has proven in many cases to be necessary.

It is never advisable on reduction gear installations to use an oil of any higher viscosity than absolutely necessary, owing to the inability of heavier oils to separate readily from water, and the danger of abnormal internal friction occurring in the lubricant, with consequent overheating of the bearings. Where heavier oils must be used the bearing clearances should be increased in proportion to the viscosity; otherwise the pressure in the oiling system should be increased to a certain extent. Both stationary and marine turbine lubricating systems and the methods of determining the suitability of turbine oils in general have been discussed in detail in LUBRICATION for February and April, 1921.

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